New Linear and Quadratic Piezoelectric Solid-Shell Finite Elements

Fessal Kpeky, Farid Abed-Meraim
LEM3 UMR CNRS 7239, Arts et Métiers ParisTech, 4 rue A. Fresnel, 57078 Metz, France
fessal.kpeky@univ-lorraine.fr, farid.abed-meraim@ensam.eu

El Mostafa Daya
LEM3 UMR CNRS 7239, Université de Lorraine, Ile du Saulcy, 57045 Metz, France
daya@univ-metz.fr

Abstract

The modeling of piezoelectric structures has been the subject of active research in recent decades (Tzou et al., 1994; Benjeddou et al., 1997; Klinkel and Wagner, 2006). However, advanced finite element technologies that are capable of efficiently modeling multilayer structures with high geometric contrast are still lacking. In this work, we propose piezoelectric extensions to recently developed solid-shell elements (Abed-Meraim and Combescure, 2009; Trinh et al., 2011; Abed-Meraim et al., 2013). For this purpose, we performed an electromechanical coupling, which consists in adding an electrical degree of freedom to each node of these elements. To increase efficiency, these elements are provided with a special direction, designated as the thickness, along which the integration points are located, while adopting a reduced integration rule in the other directions. To assess the performance of the proposed piezoelectric solid-shell elements, a variety of benchmark problems, both in static and vibration analysis, have been conducted on multilayer structures ranging from simple beams to more complex structures involving geometric nonlinearities. Compared to traditional finite elements with the same kinematics, the evaluation results allow emphasizing the higher performance of the newly developed solid-shell concept.

References

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